ICC Standard on Log Construction

ICC/ANSI 400-2005

By John "Buddy" Showalter, P.E. and Rob Pickett

With the popularity of modern log structures spreading across the country after World War II, the next several decades saw individual log homeowners, handcrafters, and manufacturers all struggling with the responsibility of complying with building codes written with conventionally framed homes in mind. In addition to a lack of any grading or design standards for assessing and utilizing logs and timbers used in log structures, other less dramatic problems such as air and water leaks, decay, uneven settling, insect infestations, and finished appearance were also seen.

Architects and engineers, as well as building officials, were identified as needing training and experience in the use of whole logs in structural applications. Uncertainty as to which, if any, structural provisions of the building codes addressed log structures was common.

In 2002, the International Codes Council (ICC) began development of a standard for design and construction of log structures. The draft standard, titled *ICC Standard for the Design & Construction of Log Structures – ICC/ANSI 400-2005*, has undergone its first public review in the ANSI standards development process. Final review and approval is expected in 2006.

Historical Approach

A traditional form of construction brought over by immigrants from Europe, Russia and Scandinavia, log structures have been built in North America since the settlers started arriving. As an indigent building material of abundance in most areas, timber was hewn with proven techniques to produce structurally sound spanning members and connections.

Much of today's log building industry does not vary from the heritage handed down by our forefathers. In fact, a substantial effort to document the techniques is evident in the prescriptive construction standards published by the International Log Builders Association (ILBA). These standards cover the construction of residential, handcrafted, interlocking, scribe-fit log walls with log floor and roof systems. However, the ILBA document is neither a consensus document under ANSI guidelines nor does it pertain to all methods of log production and construction.

As the log home market grew in the 1970's, design professionals and code officials worked with existing standards for poles, piles, and timbers to emulate performance of the log wall. Conventional framing codes and standards began to raise issues that were having an impact on the log home market to the extent that the ILBA and the Log Homes Council (LHC) were formed. The initial goals and objectives of the LHC were specifically geared toward gaining code acceptance of this traditional form of construction.

One of the first efforts funded by the LHC was to establish a grading program for logs that would satisfy requirements for graded material. A log grading standard was developed through ASTM titled *Standard D3957-90, Standard Methods for Establishing Stress Grades for Structural Members Used in Log Buildings* (ASTM 1993a). D3957 remained the only totally unbiased, sanctioned source of information regarding log construction. Industry magazines contained some design and construction information, yet the message on particular subjects still remained clouded by marketing of philosophies and proprietary systems.

In order to maintain regulatory acceptance, several log home suppliers and manufacturers secured Code Evaluation Reports with the model building code organizations. These reports, which are expensive and time consuming to develop and maintain, were not feasible for all manufacturers. The report holders also found that the reports did not provide benefits to local code acceptance that they had anticipated.

A National Standard

In 2002, the International Codes Council (ICC) applied to the American National Standards Institute (ANSI) to develop a standard for design and construction of log structures. The ICC IS-Log Committee was formed with a balance of interest groups to develop a draft. The Committee decided early on to use the format of AF&PA's *Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings* (AF&PA 2001) as a starting point for the structure of the standard. The Committee appreciated the WFCM for its multiple paths to demonstrate code compliance – a prescriptive path, an engineered path, and a test path became the model for all sections of the standard.

The standard, officially dubbed the *ICC Standard for the Design & Construction of Log Structures – ICC/ANSI 400-2005*, took the following form:

- Administrative Provisions
- Definitions
- General Requirements
- Structural Provisions

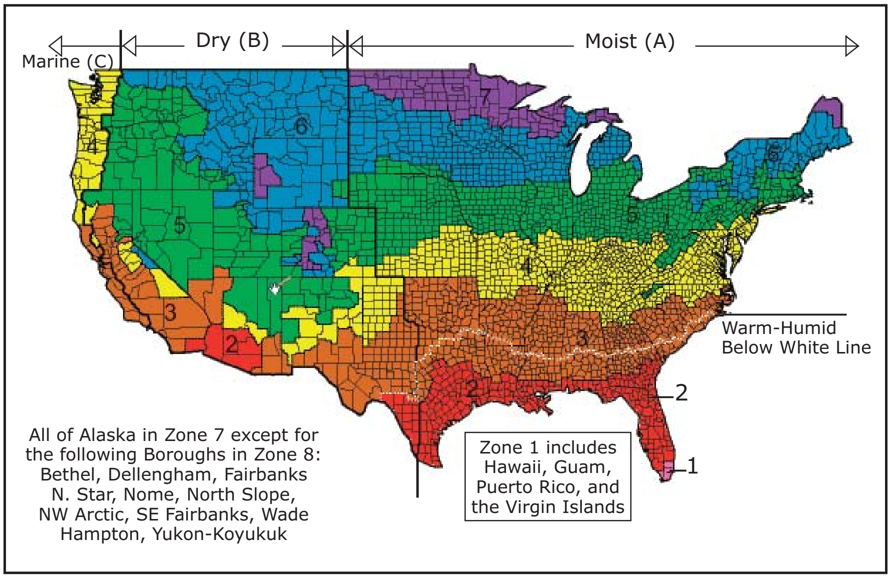

Figure 1

The scope of the standard states the following:

> **101.1 Scope**. *This standard establishes the minimum requirements for log structures to safeguard the public health, safety and welfare through structural, thermal, and settling provisions. This standard is intended for adoption by local governmental agencies and organizations setting model codes to achieve uniformity in technical design criteria in building codes and other regulations.*

General Requirements

The general requirements section contains material properties, fire resistance ratings, and non-structural provisions, such as settling and thermal envelope criteria. Material properties are based on the two nationally recognized log grading agency systems: the Log Homes Council and Timber Products Inspection, Inc. Specifically, the following tabulated information is incorporated in ICC-400:

- List of Species Combinations
- Section Properties of Round Timber Beams
- Base Design Values for Sawn Round Timber Beams
- Adjustment Factors for Wall-Logs
- Base Design Values for Wall-Logs
- Applicability of Adjustment Factors for Logs

Table 1, see page 16 excerpted from the standard, shows the section properties of sawn round timber beams and wall-logs.

Material Properties

Due to the broad variety of shapes, sizes, species, joinery, production methods, and ultimate appearance of the log wall, it was truly difficult to boil down so many variables into a standard that delineates performance. However, the standard accomplishes that by focusing on critical material properties.

As noted above, log grading programs provide design stress values to evaluate structural capacity. Equally important, those grading programs provide third-party quality assurance that allows a log producer to certify moisture content. Moisture content plays a role in determining density, which correlates to two factors recognized in the International Energy Conservation Code (IECC) for log walls – thermal resistance and mass. Previously, the equilibrium moisture content of wood was generally accepted as 12%, and calculations of thermal properties used that value. With the latest Department of Energy (DOE) revisions that have been adopted in the 2004 IECC, this is no longer generalized across North America. The Climate Zone Map (*Figure 1*) depicts four different zones to describe annual relative humidity. When tied to equilibrium moisture content analysis, these zones show that the thermal R-value of a log wall and its thermal mass will also vary by climate zone. Work done by the IS-Log Committee, with correlation of Climate Zones to equilibrium moisture content is not only a part of the developing standard, but has been incorporated into the most recent release of REScheck®, the most widely used software for energy code compliance (available at **www.energycodes.gov**).

The climate zone analysis and moisture content also play a role in estimating dimensional change, which is critical to joint design within the log wall and to establishing whether or not a log wall will change in height. This is only one element of change in a log wall that is referred to as settlement. Depending on initial moisture content of the log when produced and equilibrium moisture content on the building site, change in moisture content can result in a loss or gain in dimension. That loss or gain must be considered when designing joinery along the log. Product design can result in a log wall that ranges from non-settling (0.5% or less reduction in height over any height in question) to a prescribed option of accommodating an estimated settlement allowance of 6% of involved height. With connections, roof penetrations, stairs and other internal systems affected by change in height of exterior bearing walls, there is a distinct design impact.

As a material property of a non-conventionally shaped product, thickness of the wall becomes important. The average thickness is calculated as the area of the cross-section divided by its stack height (the exposed face or, more accurately, the distance from the center of one log to the center of the next when stacked). This is used to evaluate thermal performance of logs. For fire resistance ratings, the minimum dimension is the point of reference. The standard offers a prescriptive path that accepts a log wall as a 1-hour fire-rated assembly when the least dimension of exposed face is 6-inches thick. The standard also offers testing as an option to show that a given wall assembly performs to a particular rating.

Structural Provisions

As noted earlier, AF&PA's *WFCM* was used as a model for the structure of the standard. Therefore, early attempts were made to develop both prescriptive and engineered provisions for the standard. The engineered provisions were developed to ensure that a load path is maintained for the structure. Provisions for connections, floor, wall, and roof systems are included to remind the designer of the various elements to consider in resisting both gravity and lateral loads.

The Committee recognized that developing prescriptive provisions for the standard would entail much more time and effort than was available in the current standards development cycle. Therefore, "triggers" were built into the standard, which are used to determine when engineering is required versus prescriptive measures. For example, load triggers read as follows:

- Greater than 40-psf live load on floors
- Greater than 70-psf ground snow load
- Greater than 90 mph wind speed (3 second gust)
- Greater than Wind exposure category B
- Greater than Seismic Design Category C

Note that structures in low wind, low seismic, and low snow load regions would still be permitted to be built using prescriptive provisions. Engineering is required when these "triggers," and others like number of stories, diaphragm aspect ratios, wall height, etc., are exceeded.

Until prescriptive provisions are developed by the committee, current practice, which entails approval by a building official will still be in effect as follows:

> **402.1** *Prescriptive Provisions. Log structures not requiring engineering design in accordance with Section 403 shall be permitted to use prescriptive provisions as approved by the building official.*

Diaphragm and Shear Wall Analysis

Another area still under discussion by the Committee is the issue of diaphragm and shear wall analysis. Several research projects, involving log shear wall testing, were evaluated by the Committee. However, due to the specific nature of the research, it was difficult to develop a general approach to lateral design. One nagging issue, regarding development of seismic response modification factors (R) for log shear walls is still pending. However, subsequent to the public comments on the ICC 400 log standard, Tom Beaudette, of Beaudette Consulting Engineers (BCE), Inc., a structural engineer with over 15 years experience designing log structures, offered the following recommendation:

> "Traditional horizontally stacked log walls are directly categorized as bearing wall systems. Under the 1997 *Uniform Building Code* (UBC), an R value of 5.5 is designated for wood structural panel walls and 4.5 for all other light framed walls. This directly compares to an R of 4.5 for both concrete and steel shear walls also classified as bearing walls. We therefore also consider pinned log shear walls to have an R of 4.5.

continued on next page

Table 1

Table 302.2(2) Section Properties of Sawn Round Timber Beams

Nominal Diameter	Sawn Round Timber Beams			Unsawn (Full Round) Timber Beams		
	Area of Section	(x-x axis)		Area of Section	Section Modulus	Moment of Inertia
		Section Modulus	Moment of Inertia			
	2.8461 * radius^2	**0.6159 * radius^3**	**0.5612 * radius^4**	**2.8461 * radius^2**	**0.6159 * radius^3**	**0.5612 * radius^4**
5	17.79	9.62	21.92	19.63	12.27	30.68
5.5	21.52	12.81	32.09	23.76	16.33	44.92
6	25.61	16.63	45.45	28.27	21.21	63.62
6.5	30.06	21.14	62.61	33.18	26.96	87.62
7	34.86	26.41	84.21	38.48	33.67	117.86
7.5	40.02	32.48	110.97	44.18	41.42	155.32
8	45.54	39.42	143.66	50.27	50.27	201.06
8.5	51.41	47.28	183.08	56.75	60.29	256.24
9	57.63	56.13	230.11	63.62	71.57	322.06
9.5	64.21	66.01	285.67	70.88	84.17	399.82
10	71.15	76.99	350.72	78.54	98.17	490.87
10.5	78.45	89.13	426.31	86.59	113.65	596.66
11	86.09	102.47	513.49	95.03	130.67	718.69
11.5	94.1	117.09	613.42	103.87	149.31	858.54
12	102.46	133.04	727.26	113.1	169.65	1017.88
14	139.46	211.26	1347.34	153.94	269.39	1885.74
15	160.09	259.84	1775.54	176.71	331.34	2485.05
16	182.15	315.35	2298.5	201.06	402.12	3216.99
18	230.53	449	3681.75	254.47	572.56	5153
20	284.61	615.92	5611.57	314.16	785.4	7853.98
24	409.84	1064.31	11636.16	452.39	1357.17	16286.02

Note: Maximum allowable taper is ⅛ inch per 12 inches from tip to 36 inches from butt.

a) *These values are for timbers that are either completely round or that are sawn or shaved along only one surface such that the sawing or shaving does not exceed 3/10 of the radius of the log at any point.*

b) *The repetitive member factor,* C_r*, for bending design values,* F_b*, shall not apply to sawn round timber beams in any condition or use.*

c) *Sawn round timber beams are to be installed and protected against moisture so as to achieve equilibrium moisture content in-service. Therefore, the Wet Service Factor shall not apply.*

d) *Appropriate form adjustment factors have already been incorporated in the tabulated design values.*

The 2003 *International Building Code* has established an R of 7 for light frame walls with shear panels (wood or sheet steel). But the IBC establishes an R of 2.5 for light framed walls with shear panels – all other materials. BCE has established usage of an R of 4.0 or 4.5 (depending on the engineer) based on the following: While the values of R are largely based on engineering judgment of the performance of the various materials and systems in past earthquakes, the response modification factor (R) is based on a period dependent strength factor, a period dependent ductility factor and a redundancy factor. A pinned log wall collects and distributes lateral forces similar to a wood sheathed shear wall element. Energy dissipation (dampening) is considered to be very similar to sheathed wood shear walls. The elastic behavior of the pinned wall imitates the light frame shear panel walls. Further, a regularly spaced pinned log has considerable system redundancy.
The combination of the above noted factors allows justification for a seismic response modification coefficient for regularly spaced pinned log walls to be equal to that of the wood sheathed wall panel. The tighter spaced, small diameter log walls (pins or fasteners at 12 to 18 inch o/c) could have a higher R values (R = 5.5 or 6.0). While a typically spaced large diameter log wall (large steel pins from 24 to 48 inches o/c max) can conservatively have an R of 4.0 to 4.5. Log walls systems which rely on through rods at openings and corners only, should have a low R value of 2.5. BCE does not design log walls systems without regularly spaced pins (max 48-inch o/c), therefore we have established a 2003 *IBC* Response Modification Coefficient R of 4.0 or 4.5. The 4.0 to 4.5 value is used for tighter pinned spaced log walls also.”

Impact

Once the ICC 400 standard is approved and begins to be adopted by local jurisdictions and referenced in future editions of the *International Building Code* and *International Residential Code*, there will be both short-term and long-term effects. Immediate impacts include:

- Uniform enforcement of grading requirements
- Uniformity in code analysis and enforcement
- Quick reference for technical data
- 1-hr. fire-resistance ratings for log walls
- Wall assembly thermal R-values
- Section properties of round and sawn round shapes

Long-term implications include:

- Broader acceptance with growth of ICC adoption at various levels of government
- Updating of the standard every code cycle
- Coordination with international code bodies governing imports and exports

Conclusion

ICC 400 represents a first step to standardizing design and construction provisions for log structures. A majority of log structures in low wind, low seismic and low snow load regions will still be permitted to use conventional prescriptive provisions. Only those structures that exceed certain limitations will require engineering analysis. This trend is similar for conventional wood frame structures as well.▪

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